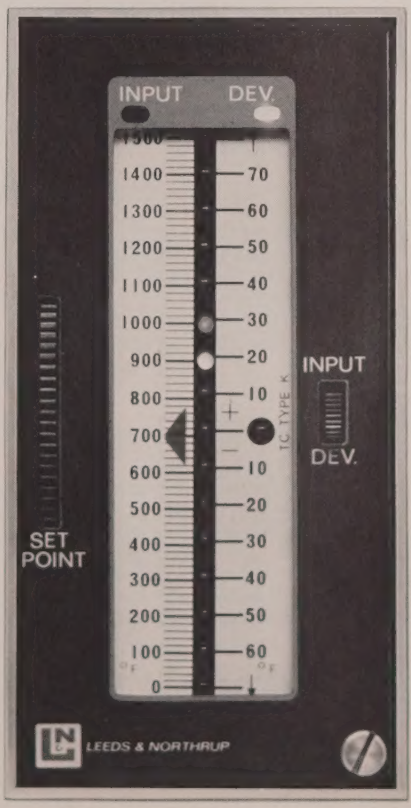
DIRECTIONS 177946 *Rev.* **B**
Supersedes Issue 1

STAR™ I

2023 P.E.T. (POWER ELEMENT TRIGGER) INDICATING CONTROLLER

- Simple, reliable, low-cost control
- Unique LED display of input or deviation value, switch-selected
- Thermometer-type vertical temperature display: 16 variable intensity red LEDs read against direct-reading "Input" scale
- LED display of deviation, read against "Deviation" scale (green at set point, red above or below)
- Control set point precisely positioned by large serrated thumbwheel projecting through front panel — indicated by split red arrow on vertical scale
- Solid-state triac output
- Adjustable proportional action with manual or automatic reset
- Accepts low level signals; failsafe standard for thermocouples
- All-solid-state vibration-resistant construction — no deflection meters, no plug-in connections, lockable set-point setter
- Continuous 0-4 V dc output, proportional to input, for recording or retransmitting
- Optional input or deviation alarm — high and/or low — with red alarm light on front panel
- Compact DIN-standard case for panel-mounting



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SPECIFICATIONS

INPUT SOURCES

Millivolt or millampere.
Thermocouple: compensation for types J, K, R, S, and T.
Resistance Thermometer: accepts 100 ohm platinum 3-lead type.

FAILSAFE

Thermocouple break protection, upscale is standard, downscale is optional.

SOURCE IMPEDANCE

2000 ohms, Maximum.

INPUT RANGES

Spans of 10 minimum to 100 mV maximum.
Maximum zero elevation or suppression: 100% of calibrated span.
Current ranges: an internal shunt is provided.

INPUT IMPEDANCE

Greater than 0.5 megohms.

INPUT SENSITIVITY

5 microvolts.

SET POINT

Analog indication on direct reading input scale.
Adjustment: by thumbwheel on front panel, moves pointer over the input scale.
Internal locking device on thumbwheel.
Accuracy: ±1% of full-scale at reference conditions.
Resolution: ±0.5% of full-scale.

PANEL DISPLAY

Slide switch selected: scale in use is indicated by LED-illuminated "INPUT" or "DEV" legend at top.
Input: Sixteen variable-intensity red LEDs provide thermometer effect, read against 100-mm calibrated vertical scale at left. (As input increases, each LED changes gradually from off to bright in sequence, permitting readability between LEDs.)
Deviation: Indicated against right-hand deviation scale by variable intensity LEDs—eight red above set point, one green at set point, seven red below set point. (With zero deviation, the green LED glows; as input moves from set point, the green LED extinguishes and a single red LED (or two adjacent, varying from dim to bright) indicates the deviation. If deviation exceeds scale value in either direction, top or bottom LED remains on.)

SPECIFICATIONS

OUTPUT

A zero-fired triac circuit proportions the ON and OFF time during a fixed time base of approximately 1 second.
Triac Rating: 1 kW at 120 V, 60 Hz (minimum load 75 W) or 2 kW at 240 V, 60 Hz (minimum load 150 W).
Peak off-state voltage: 400 V
Load: non-inductive, (power factor >0.8)
Peak inrush current: 40 Amps.
Fuse (user supplied): 10 Amps maximum, I^2t rating should provide blowing times of 5 milliseconds at 100 A and 10 milliseconds at 70 A.
Isolation: The output is isolated from the input.

CONTROL ACTION

Reverse (Standard) — triac is pulsed ON when input is below set point. Direct (Optional) — triac is pulsed ON when input is above set point.

CONTROL SENSITIVITY

2 microvolts.

FREQUENCY RESPONSE

1 Hz.

CONTROL ADJUSTMENTS

Proportional Gain, with Manual Reset: 1 to 50 (100% to 2% proportional band); with Automatic Reset: 1 to 200 (100% to 0.5% proportional band).
Manual Reset: 0 to 100% of output, adjustment knob on front panel.
Automatic Reset: 0.05 to 5 repeats per minute, adjustment behind front panel.

AUXILIARY OUTPUT

0 to +4 V, proportional to input range.
Over-range limits: –0.75 V and +15 V.
Minimum Load Impedance: 5000 ohms. The auxiliary output is not isolated from the input.
Accuracy: ±0.5% referenced to input span at reference conditions.

NOISE REJECTION

Common Mode: 120 dB at 120 V rms maximum.
Normal Mode: 45 dB at 0.5 V rms maximum.

TEMPERATURE EFFECT

±9 $\mu V/^{\circ}C$ (±5 $\mu V/^{\circ}F$).

LINE VOLTAGE EFFECTS

A ± 10% variation will affect accuracy by 0.25% of span max.

THERMOCOUPLE COMPENSATION

Automatic: for type J, K, T: ±0.25% of span.
Automatic: for type R, S: ±0.4% of span.

SPECIFICATIONS

TEMPERATURE LIMITS

Operating: Triac Output: 0 to 50 C (32 to 120 F)*
Storage: -10 to 60 C (14 to 140 F)

ALARM OPTION

For Input (0-100%) or Deviation (0 to ±5%) signals.
Contact: A Form "A" SPST (N.O.) relay, rated at 5 A, 240 V ac or 30 V dc, non-inductive loads.**
Red alarm lamp on panel indicates when relay closes.
Set points adjustable internally by High and/or Low setters.
Repeatability: ±1% of span.

RELATIVE HUMIDITY LIMIT

90% maximum at 40 C (104 F).

VIBRATION

Withstands 0.5 g, from 0 to 60 Hz, with setter locked.

POWER, CONTROLLER

107 to 127 V, 60 Hz, 9 VA.
Customer supplied fuse for controller: 0.1 A.

NOTE: Power for the triac and power for the controller must be the same phase.

CASE

Extruded aluminum case with die cast bezel and gasket.***
Chassis stop permits forward movement of 65 mm, allowing access to routine adjustments, without interrupting operation.
All connections are to a terminal board at the rear of chassis.
Dimensions: 72 mm (2.84") wide x 144 mm (5.67") high x 154 mm (6.06") deep (DIN standard).

MOUNTING

For panel mounting, per DIN 43700. See Fig. 4.

WEIGHT

Approximately 1.82 kg (4 pounds).

**Assumes free air space around case.*

***For inductive loads an arc suppressor (Part 144139) is recommended across the relay contacts.*

****A dust cover is available for the rear of the case: Part No. 008813.*

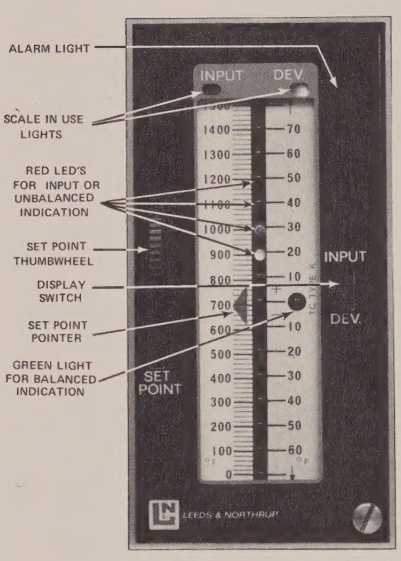


Fig. 1 — Front View of the 2023 P.E.T. Controller.

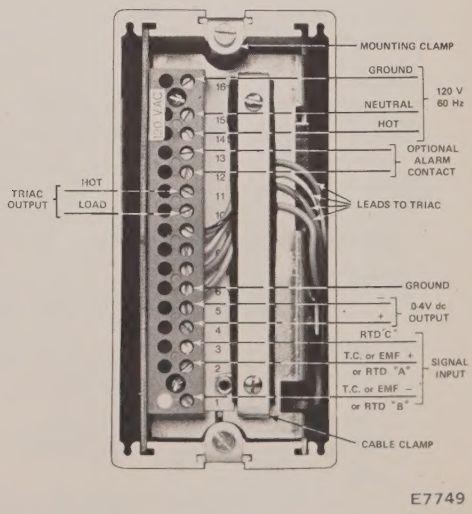


Fig. 2 — Rear view of the case showing terminal board and electrical connections.

STAR I
2023 P.E.T. (POWER ELEMENT TRIGGER) INDICATING CONTROLLER

PART I — INTRODUCTION AND DESCRIPTION

1. INTRODUCTION

The Catalog 2023 Star I Indicating Controller, shown in Figs. 1 and 2, is a solid state instrument designed for applications where proportional control of electric power to a process is desired. A typical process is shown in the block diagram of Fig. 3. These controllers accept low-level millivolt input signals from sensors, including thermocouple and resistance thermometers. The selected control point is shown by a pointer on a vertical direct-reading scale on the left side, corresponding to the input range of the unit. On the right side is a deviation scale. A display consisting of series of LED lamps between the two scales, either indicates input level or deviation from the control point.

The proportional action of the controller changes the output power of the triac in proportion to how far the input signal deviates from the control or set point. Proportional action alone will not bring the input signal back to the set point; usually a slight offset or "droop" exists after the process settles. Automatic reset (integrating action) is added to eliminate this deviation. The amount of reset action for a given setting is dependent on how far and how long the process is away from the control point. For some processes, notably of the batch type, even small amounts of reset action can cause overshoot and oscillation in the controller variable. In such processes, manual reset is used, after the process settles, to manually change the output slightly to correct for any deviation from set point.

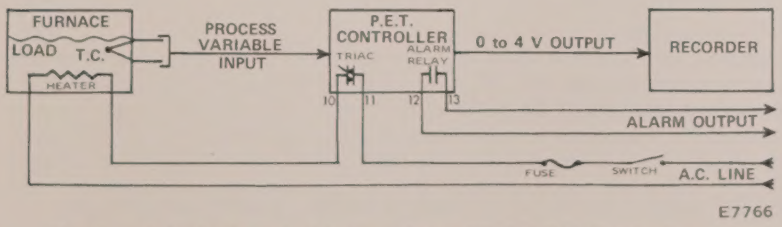


Fig. 3 — A typical control loop, using a 2023 P.E.T. Controller.

An auxiliary output signal of 0 to 4 volts, proportional to the input range, is provided for operating auxiliary equipment such as recorders.

An alarm option provides a relay closure and panel lamp indication of critical conditions.

The controllers are factory calibrated to agree with the range, and do not require the user to make any adjustments with the exception of setting the optional alarms, and tuning the Proportional Gain and Reset adjustments to match the process.

2. CATALOG NUMBER

Table I shows the available options and their catalog numbers. These numbers appear on labels affixed to both the case and chassis.

TABLE I — CATALOG SYSTEM OF THE STAR I P.E.T. CONTROLLER

A B C D
Catalog Number 2023—□□□□—6—□□□

Suffix A — Basic Unit
Power-Element-Trigger Controller

Suffix B — Range
Range Number

Suffix C — Power Supply

120 V, 60 Hz	**6**

Suffix D — Options

None	**000**
Automatic Reset	**010**
High and Low input alarm	**020**
High and Low deviation alarm	**021**
Low input alarm	**022**
High input alarm	**023**
Low deviation alarm	**024**
High deviation alarm	**025**
Direct Acting control	**040**
Downscale Failsafe	**045**
Linen Tag	**206**

Upscale failsafe is standard for TC inputs, by adding a jumper on terminal board.

3. DISPLAY SYSTEM

The process-variable input signal and the deviation of this signal from the set point are uniquely indicated on two adjacent vertical scales, 100 mm in calibrated length. The scales share 16 equally-spaced, variable-intensity red LED's. One green LED is located at the set point on the deviation scale. A slideswitch, marked DEV/INPUT, is used to select the desired display, which is indicated by an LED above the appropriate scale.

In the INPUT mode, as the signal increases, each LED goes on in ascending order, changing gradually from off to bright. This thermometer effect provides an exceptionally clear indication of measured value against the left scale.

In the DEViation mode, with the signal at set point, the green LED is brightly lit. As the input deviates from set point, the green LED dims, and a red LED, above or below set point, brightens. For any deviation, only one LED, or two adjacent lamps at variable intensity, are lit. Values between divisions on the deviation scale can be readily estimated by the intensity of adjacent lights. If deviation goes offscale, the top or bottom LED remains lit, indicating the direction of deviation.

4. SET POINT INDICATOR

A large serrated thumbwheel extends through a vertical slot in the front panel. This permits precise adjustment of the control set point by positioning a split red arrow indicator along the vertical input scale. An internally-mounted slide lock can be meshed with the teeth on the perimeter of the wheel to prevent accidental shifting of the set point. Graduations on the face of the wheel facilitate repeatability of set point positions when changes are required.

5. OUTPUTS

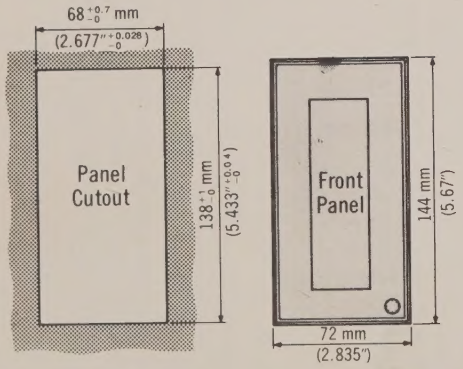
—Control

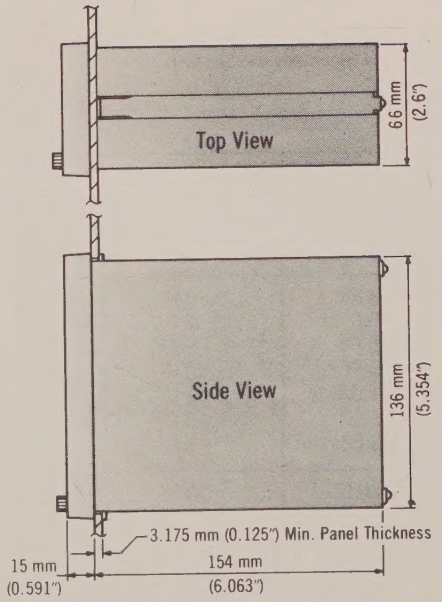
The controller is supplied with a triac for the output signal. The triac keeps power ON for a portion of each 1-second period. The duration of the power pulse can vary from 0 to 100% of the 1-second period. At set point, the power output will remain at a nearly constant percentage level to keep the process signal from changing. If the process deviates from the set point, the length of each ON pulse becomes longer or shorter, depending on the power needed

NOTES:

Minimum space between adjacent panel cutouts (hor. or vert.) is 10 mm (0.393").

Allow 178 mm (7.0") front clearance for removal of chassis from case.





PANEL CUTOUT DIMENSIONS FOR MULTIPLE UNITS MOUNTED SIDE BY SIDE

No. of Units in Panel Opening	2	3	4	5	6	7	8	9	10
Panel Opening Width	5.482 ±.020 139.25 ±.5 MM	8.315 ±.020 211.20 ±.5 MM	11.150 ±.020 283.20 ±.5 MM	13.986 ±.020 355.25 ±.5 MM	16.821 ±.020 427.25 ±.5 MM	19.655 ±.020 499.25 ±.5 MM	22.490 ±.020 571.25 ±.5 MM	25.325 ±.020 643.25 ±.5 MM	28.161 ±.020 715.30 ±.5 MM
Bezel Width	5.670 144 MM	8.505 216 MM	11.340 288 MM	14.175 360 MM	17.010 432 MM	19.845 504 MM	22.680 576 MM	25.515 648 MM	28.350 720 MM
Trimplate Width	6.969 ±.031 177.01 ±.8 MM	9.813 ±.031 249.25 ±.8 MM	12.641 ±.031 321.08 ±.8 MM	15.469 ±.031 392.91 ±.8 MM	18.313 ±.031 465.15 ±.8 MM	21.141 ±.031 536.98 ±.8 MM	23.984 ±.031 609.20 ±.8 MM	26.813 ±.031 681.05 ±.8 MM	29.656 ±.031 753.27 ±.8 MM

Fig. 4 — Mounting and dimension drawing.

to re-balance the process. If the controller has reverse acting (standard) control, the power pulses will increase if the input drops below the set point, and decrease above the set point. With direct acting control (Option 040), the power pulses increase as the input goes above the set point, and decrease if the input goes below set point.

—Failsafe

For thermocouple input signals, upscale failsafe is a standard feature. A signal failure would then result in upscale controller action. Optional downscale failsafe is available.

—Auxiliary

A continuous 0 to 4 volts dc output signal, proportional to the input, is standard on all controllers; this can be used for operating recorders or other devices.

—Alarm

One input alarm or one deviation alarm, high and/or low, can also be supplied. A red indicator light is then supplied on the front panel

PART II — INSTALLATION

6. UNPACKING

The following documents are supplied with each Star I Controller.

Direction Book (includes the Mounting and Dimension Drawing, Fig. 4)
Installation Wiring Diagram for specific controller.

The dimension and wiring diagrams contain details for mounting and wiring the controller. Read each note carefully. A number of controllers may be mounted in one panel cutout; see the dimensions given on the diagram.

The case and controller are packed together. It is not necessary to separate the controller from the case before panel mounting the case. Should it be necessary to separate the chassis from the case prior to mounting, see Part IV of these directions.

Follow all instructions on any tags attached to the case or controller. Check all interconnecting wires at the terminal board to be sure they are tight.

7. MOUNTING

The controller case is designed for panel mounting. For best results locate the controller in an area where the ambient temperature is within 32 to 120 F (0 to 50 C).

The controller contains a power triac; the location should allow free air convection around the rear and sides of the case to prevent overheating.

To mount the case:

(a) Cut an opening in the panel for the case as shown on the Dimension Drawing, Fig. 4. If the opening is accidentally cut too large, obtain a Trimplate Kit from the factory (Part No. 225155). Trimplates for multiple-mounting panel openings are listed in the Parts List.

(b) Remove the two jacks at the top and bottom of the case by removing the jack screws and jacks located at the back of the case; see Figs. 2 and 4. The case can now slide through the panel from the front.

(c) At the rear of the panel, hold the case perpendicular to the panel, slide the jacks into the outside case guides, put the screws back in, and tighten the jacks against the back of the panel.

8. WIRING

The following wiring procedure must be adhered to in order to obtain the performance described in the Specifications. The most important wiring considerations are (1) proper grounding, (2) segregation, of input signal wires and (3) arc suppression for relay contacts with inductive loads (for alarm option relay).

Power from a *switched and fused* 120 V, 60 Hz supply is required for the controller.

Wire sizes listed in Table II should be considered as the minimum sizes recommended for good operation. Stranded wire should be used because of the flexing required as the chassis is pulled forward for servicing. As shown on the wiring diagram, a loop of wire should be provided to allow for this flexing. Individual terminals on the terminal board are capable of handling one size #14 or two size #16.

TABLE II — RECOMMENDED WIRE SIZES

AWG SIZE	USE
14	Earth ground wire
14	Ac power to output triac
18	Ac power to controller circuits
18	Alarm, and Auxiliary output
20	Dc input leads

Make all connections at the main terminal block allowing sufficient lengths of leads to enable the chassis to be drawn forward to the chassis stop position. Make the terminal connections in accord with the wiring diagram supplied with the unit. Fuses and line switch must be supplied by the user.

Arrange all cables under the clamp in such a manner as to provide the best flexing arrangement when the chassis is pulled forward.

8A. Grounding

The ground used should be an instrument ground or other bus tied directly to ground. A copper water pipe often provides an excellent earth ground.

When an instrument ground is not available, the ground lead of the power source may be used; this is usually a green wire. Under no circumstances should the neutral side of the ac power line be used as the ground connection.

8B. Input Wiring

The input signal leads such as thermocouple wires should not be run parallel to or in the same conduit with the ac power lines in order to avoid coupling high level ac signals into the low-level input lines.

The type of primary element to be used with the controller is indicated on the right side of the controller's scale.

For thermocouple input ranges, connect the thermocouple extension wires to terminals 2(+) and 1(-). Emf inputs connect to the same terminals; for minimum noise pickup on long runs, use a twisted pair of leads. For thermocouple failsafe, connect a jumper from terminal 2 to 3. If the optional downscale failsafe is supplied, the same two terminals are jumpered. For a current (mA) range, connect the current source to terminals 1(-) and 2(+). The shunt resistor is built into the controller and does not have to be added.

Resistance Thermometers must be of the three-lead type, compatable with the range of the controller. The equal-resistance leads must be connected to terminals 1 and 2. The remaining lead (common to the lead going to terminal 1) connects to terminal 3.

8C. Output Connections

Connect the HOT side of the ac line through a switch and fuse* to the (triac) terminal 11. Connect one side of the load (up to 1 kW, but not less than 75 W for 120 V or 2 kW, but not less than 150 W for 240 V) to terminal 10, and the other side of the load to the neutral side of the ac line. *The ac line must be the same phase as the ac used to power the controller.* Note that the controller output is isolated from the input. The load must be non-inductive with a power factor of not less than 0.8 and the peak in-rush current limited to a maximum of 40 amperes.

NOTE: Terminal 9 is internally connected to terminal 10; similarly, 7 is connected to 11.

8D. Alarm Connections (Options 020 to 025)

The Alarm Output is a Form "A", SPST (N.O.) relay contact. The connections are made to terminals 12 and 13. Do not exceed the specified contact limits of 5 A, 240 V ac or 30 V dc (resistive). For inductive loads see the Arc Suppression section, below.

**The user supplied fuse should have a I^2t rating to provide blowing times of 5 milliseconds at 100 A and 10 milliseconds at 70 A.*

9. ARC SUPPRESSION

An arc suppression circuit is recommended when an inductive load (i.e., contactor coil) is connected to the relay output of the deviation or input alarm.

Arc suppressor 144139 (0.02 μF in series with 47 ohms), across the terminal board connections for the relay contacts, will prolong contact life and minimizes radio frequency interference (rfi) generation. The presence of excessive rfi is indicated by sporadic movement of the deviation display unrelated to input signal changes.

PART III — OPERATION

10. STARTUP PROCEDURE

The controller is factory calibrated, however the user may want to check operation before putting it into service. Use the following procedure. Do not touch any adjustments unless told to do so.

—Temporarily replace the input signal connections with a millivolt source such as an 8690 Potentiometer.

—Unscrew the knurled fastener on the front panel and pull the chassis out to the stop. Move the proportional adjustment pot to the center of travel. For units with automatic reset (Option 010), set the adjustment at 5 rep/min. Units with the manual reset adjustment on the front panel should have this adjusted to the center of travel. Move the set point adjustment thumbwheel to the center of the scale.

—Check that all connections have been made, and then turn on the power to the controller, but not to the triac output circuit. If no panel lamps come ON, recheck the controller power source.

—Move the panel switch to the INPUT position. The LED's should show the level of the input signal. Raising the input signal should make the additional LED's go on, giving the "thermometer" effect against the input scale.

—Line up the set point pointer with the uppermost LED that is on. Move the panel switch to the DEV position. The center green LED of the deviation scale should be on. If not, make a minor adjustment of the input signal or the set point thumbwheel until the green lamp is on.

—Increasing the input signal or moving the set point down should make the green lamp go off and the individual red LED's above the "O" deviation point will go on. Halfway between any two LED's, both lamps will be on dimly. Similarly, decreasing the input signal or moving the set point above the input signal level will make the LED's below the "O" deviation line go on.

—Check the output of the triac; first turn the power ON to the triac/load circuit. The triac turns power ON for a portion of each 1-second period. The duration of the power pulse can vary from 0 to 100% of the 1-second period. At set point, the power output will remain at a nearly constant

percentage level to keep the process signal from changing. If the process deviates from the set point, the length of each ON pulse becomes longer or shorter, depending on the power needed to re-balance the process. If the controller has reverse acting (standard) control, the power pulses will increase if the input drops below the set point, and decrease above the set point. With direct acting control (Option 040), the power pulses increase as the input goes above the set point, and decrease if the input goes below set point. To show these effects, the set point can be moved slightly above and below the input signal level, simulating the effect that an unbalance creates.

Do not accidentally short the triac output terminals or the load to ground or the triac may become damaged. If there is no output, check the triac power source.

—Units with manual reset: Note, the following procedure is for the standard reverse-acting control, with directions for direct-acting units given in parenthesis.

To check the time proportioning operation, increase (decrease) the input signal slowly until the pulse action of the triac just stops. (The repetition rate is 1 per second.) Lower (raise) the input signal by an amount equal to approximately 25% of full scale. The output timing cycle should become 50% ON and 50% OFF. Reduce (raise) the input signal an additional 25% of full scale, or move the set point pointer in the opposite direction. The output should remain ON now for 100% of the time. The above test can be repeated with the manual reset pot at different settings, noting that the ratios of ON and OFF times will change.

—Units with automatic reset: Note, the following procedure is given for units with the standard reverse-acting control, with directions for direct-acting units given in parenthesis.

Make certain that the panel switch is in the DEV position. Slowly adjust the input signal so that the output just changes to a full OFF condition. Change the RESET to 0.5 rep/min. Raise (lower) the set point dial enough so that the bottom (top) LED just comes ON. The output triac now should change from a pulsing ON and OFF to a full ON condition in approximately 4 minutes.

—The controller has been calibrated with the display switch in the DEV position. A slight calibration change (max 0.5%) may be noticed with the switch in the INPUT position.

—To check failsafe action, place the panel switch in the INPUT position. Momentarily disconnect one of the input signal leads. For upscale failsafe in the input LED's should all light; for downscale they should all go out except the bottom one. If the failsafe does not perform as described, check that the jumper is installed between terminals 2 and 3.

—To complete the startup procedure, the optional alarms must be set.

The following section describes this adjustment. If this adjustment is not needed, disconnect the millivolt source and re-connect the input signal leads.

11. ALARM ADJUSTMENT

The optional alarms are not set at the factory. The setters are marked H and L and are accessible from the top of the controller when the chassis is pulled out to the stop. See Fig. 5 for location of the adjusting pots. Unscrew the

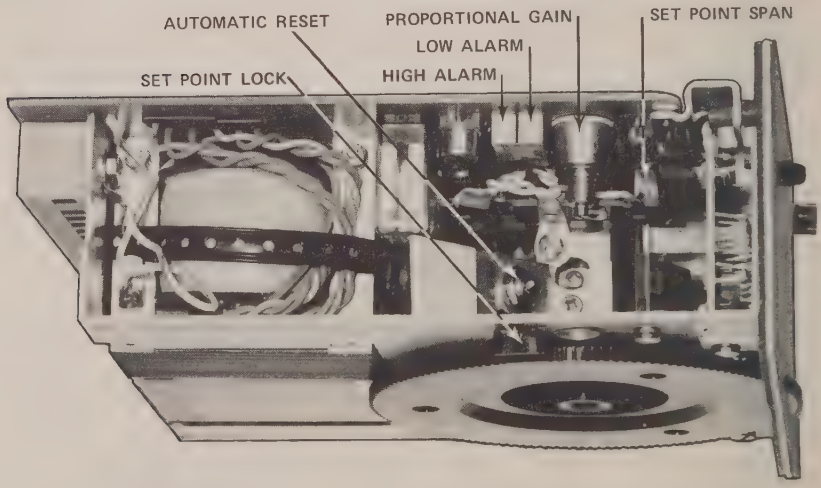


Fig. 5 — Chassis out of case showing location of adjustments.

thumbscrew on the panel face several turns; pull on the thumbscrew to withdraw the chassis part way. Note in the following sections that the units that have only one alarm specified will still have both of the adjusting pots, however only one will have any effect. The alarm light on the upper-right corner of the front panel will show the condition of the alarm relay. Turning either adjustment pot clockwise will raise the actuation point.

11A. Deviation Alarm

Move the display selector switch to the DEV position. Adjust the input signal or the set point thumbwheel to obtain the desired deviation alarm setting as indicated by the deviation display lights. Adjust H and/or L until alarm action occurs. The high and low alarm settings should not be set too close to each other, otherwise the relay may remain on. This procedure may have to be repeated before the correct setting(s) are obtained due to interaction between the two adjustments. The maximum limits of the settings are slightly greater than the extremes of the deviation scale.

11B. Input Alarm

Move the display selector switch to the INPUT Position and adjust the input signal to obtain the desired input alarm setting. Adjust setter H and/or L until alarm action occurs at the desired point(s). The limit of adjustment is 0 to 100% of the input range, however, where both high and low alarm settings are made, the two points should not be too close together or the relay may remain closed all the time.

12. TUNING THE CONTROLLER TO THE PROCESS

—For initial adjustments, pull the controller chassis out to the stop. Set the proportional gain at the clockwise end (minimum gain), and the automatic Reset to the minimum setting, or 0.05 Repeats/Minute. The manual Reset knob on the front panel should be at the center of travel. Adjust the set point wheel for the desired process level. Move the INPUT DEV switch to the DEV position.

—The proportional gain should be increased (counter clockwise direction) in small steps, until the deviation display lights indicate that the process is cycling steadily. Note the frequency of this cycling. Be sure to allow enough time for the process to stabilize after each change to the settings. Reduce the proportional gain sufficiently (clockwise) to eliminate the cycling.

—For units with automatic Reset, introduce reset action by turning the adjustment clockwise in small steps. Wait for the system to stabilize after each change. When the system cycles at a frequency which is lower than that observed for porportional action alone, the Reset should be reduced to eliminate the cycling.

—Manual Reset Units: After the Proportional Gain has been set, the process should stabilize at or near the set point. To return the process to the set point, turn the manual Reset knob clockwise to raise the process variable, or counterclockwise to lower it. This adjustment should be done in small steps, allowing sufficient time for the process to change and stabilize after each adjustment.

—Summary. Tune the Proportional Gain and automatic Reset adjustments for maximum stable settings, without cycling of the input signal.

Eliminate or reduce cycling from one or more causes starting with the higher frequency (Proportional Gain).

Allow sufficient time after each adjustment for the system to stabilize.

If the cycling cannot be eliminated, tune for minimum frequency and amplitude.

13. CONTROL LOOP OPERATION

If the control loop fails to function properly, check the connections to each unit or device in the system, then check each unit for proper operation. If the fault is traced to the controller, follow Section 10, (Startup Procedure) to check out the controller circuits. To check calibration or replace components, see Part IV, Servicing.

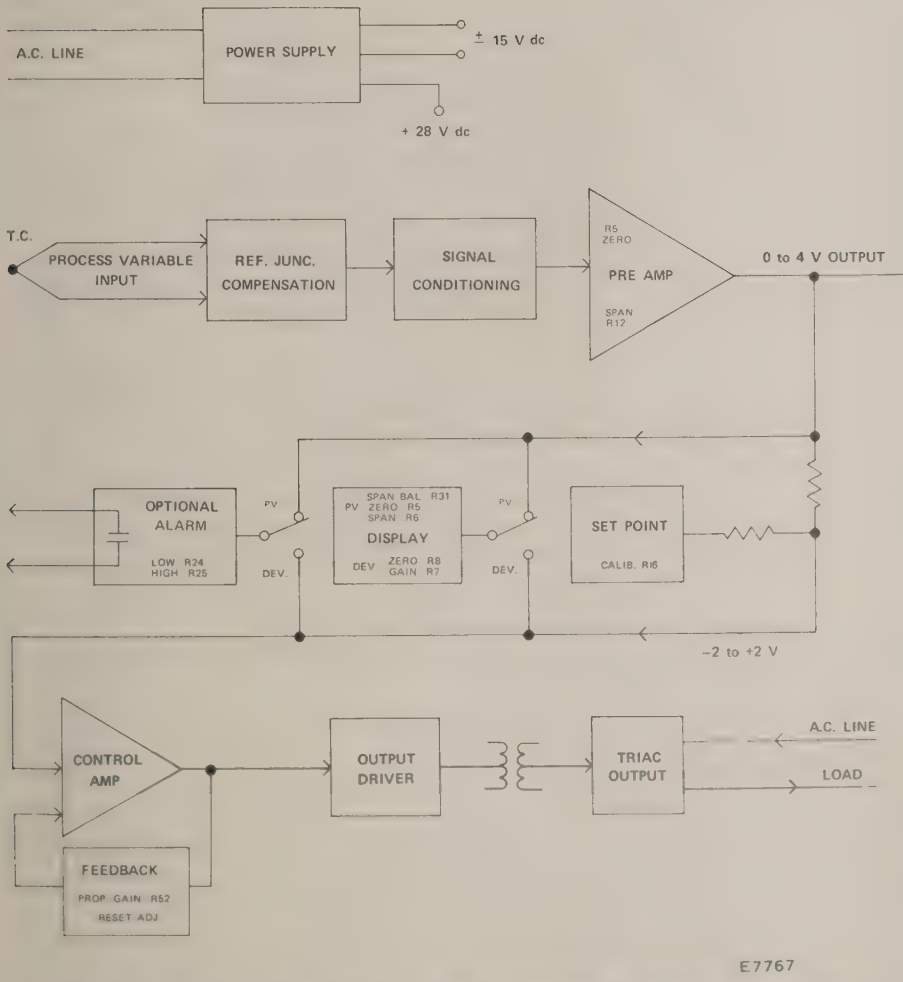


Fig. 6 — Block diagram of the 2023 Controller showing appropriate adjustments.

PART IV — SERVICING

14. CIRCUIT DESCRIPTION

For general information the following circuit description is given. Refer to the block diagram (Fig. 6) for clarification. Note that the adjustments associated with a given portion of the circuit are shown.

The input signal is first filtered and then pre-amplified. The resulting high-level voltage is compared with an internal reference voltage established by the analog setter which is mechanically coupled to the set point arrow on the input scale.

The difference between these two voltages is fed to the control amplifier which provides proportional gain (proportional action) and, for option 010, automatic reset (integral action). The output from this amplifier feeds the traic driver which provides output pulses synchronized with the line voltage for zero-voltage firing of the integral triac when the input passes set point. With the output pulses applied to the triac, the line voltage is switched on to the load.

15. CALIBRATION

15A. Test Equipment

The following items are necessary for checking calibration.

1. Digital voltmeter (D.V.M.) with 0.1% accuracy.
2. Calibrated dc source such as the L&N 8690 Potentiometer, or a current source to simulate the input signal.
3. For RTD inputs, a calibrated decade resistance box, accurate to ±0.001 ohms.
4. For Thermocouple inputs; reference tables such as L&N 177610 and room temperature thermometer. For resistance thermometer inputs, use L&N Thermohm® Tables, No. 177586.

15B. Calibration Procedure

—Temporarily, turn off the power to the triac and to the controller. Replace the input connections with the calibrated mV test source or resistance box. Partially withdraw the chassis from the case. For T.C. inputs, place the thermometer at the terminal board. *NOTE: For the following procedure, it is recommended that the controller be energized for at least 2 hours before adjustments are made.*

—Adjust the test source for the low end of the input range. For thermocouples, obtain this millivoltage (and also for the high end of the range) by looking up the upper and lower range temperatures, and subtracting from these values the mV corresponding to the temperature on the terminal board.

Example: Range #4372, 0-500 F for type J thermocouples.

Low end (0 F)	=	-0.89 mV	High end (500 F)	=	+14.11 mV
Room Temp. (86 F)	=	-1.54 mV		=	- 1.54 mV
Low end input	=	-2.43 mV	High end input	=	12.57 mV

—Connect the DVM across the auxiliary output terminals (4+ and 5–); set the range switch for measuring 0 to 4 V, ±0.01 V. Adjust the ZERO pot (R5) located on the bottom of the circuit card, until the output is 0, ±0.01 V. Change the input to the high-end setting. The output should be 4 V, ±0.01 V; if not, adjust the GAIN pot (R12), which is in the same location as R5. Repeat these two adjustments until no further change is required.

—Move the set point thumbwheel to line up the pointer with the high end of the input scale. Set the display switch in the DEV position. Adjust the input source for the high end of the input range.

—Move the DVM + probe to the slider of the set point pot.* The voltage should be 0, ±0.04 V. If not, recheck the ZERO and GAIN adjustments, and make certain that the input source being used is accurate. If it is correct, adjust the set point calibration pot R16, to get 0.0, ±0.04 V. See Fig. 4 for the location of this pot.

16. TRIAC REPLACEMENT

If all of the above adjustments are satisfactory, but the output is not working, the triac is probably defective. To replace the triac, see Section 19: Removal of Chassis From Case, and the following procedure

—The triac is mounted on the inside surface of the case. Remove the assembly using a 1/4" wrench. Remount the assembly to the side of the case, being sure to place a small quantity of silicone grease between the triac and the case.

*The set point potentiometer is the one turned by the thumbwheel. The three connections for this potentiometer go through the circuit card to which they are soldered. The slider is the lower left pin of these, accessible on the right side of the chassis.

17. ALARM RELAY REPLACEMENT

To replace the alarm relay, see Section 19: Removal of Chassis From Case, and the following procedure.

—The alarm relay is located between the alarm adjustment pots and the power transformer. The solder must first be removed from the circuit card where the relay is mounted.

Use a low-wattage soldering iron and fluxed-copper braid, such as "Dri-Wick", (American Beauty, Catalog 484-3). Carefully pry the relay away from the circuit card. Mount the new relay in position and solder it using a minimum of heat with small-diameter rosin-core solder.

18. ALARM LAMP REPLACEMENT

The red alarm lamp has in-line connectors in the leads which go to the circuit card. To replace the lamp, pull the chassis out to the stop. Unscrew the lamp mounting bracket from the circuit card. Pull the connectors apart, being carefull not to damage the set point indicator tape. Pry off the locking ring from the defective lamp assembly and remove it from the bracket.

Mount the new lamp similarly, pressing the new locking ring down over the lamp base until it is snug. Remount the bracket on the circuit card. Connect the wires to the connectors.

19. REMOVAL OF CHASSIS FROM CASE

(a) Be sure all power to the controller is disconnected including the power supply to the triac load circuit and alarm relay circuits where applicable.

(b) Remove the cable clamp and disconnect all wires noting their terminal identity number.

(c) Unscrew the knurled screw on the front face of the controller and pull the chassis forward until the stop position is reached.

(d) Insert a thin screwdriver through the small hole in the bottom center of the front flange on the case (Fig. 7) and, using it as a lever, lift the stop spring foot clear of the case casting which will enable the chassis to be fully withdrawn.

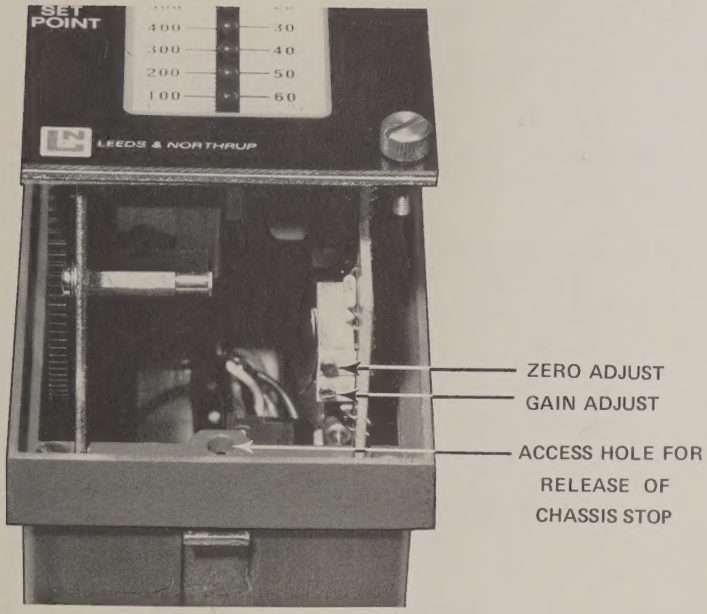


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Fig. 7 — Bottom view showing access hole for chassis stop catch.

Observe the following precautions:

The terminal block construction incorporates a spring member in each terminal point to prevent the clamping screws from cutting into the cable.

Before replacing the chassis it is advisable to be sure that clear access for the cables is provided by loosening the clamping screws in the terminal block and deflecting the spring member where necessary. Take care when releasing the clamping screws as they are not held captive to the terminal block when fully unscrewed.

If a number of units of differing specifications have been completely withdrawn from their cases, make sure that the serial number on the chassis is the same as the case when reassembling.

19A. Replacing Chassis In Case

When replacing the chassis in its case, be sure that the chassis stop catch locates in the slide slot of the case assembly. Check that the chassis stop now works effectively.

When remaking wiring connections to the terminal block and replacing the cable clamp, allow for free lead length as explained in Part II, Installation Wiring.

20. REPLACEMENT PARTS LIST

Triac Assembly	445533
Silicone Grease for the triac (Dow Corning 340)	820195
Alarm Relay	036554
Alarm Light (red) with leads	026315
Arc Suppressor for relay contacts	144139
Manual Reset Knob	002368
Rear Dust Cover, w/mtg. drawing	008813

TRIMPLATE KITS TO ADAPT THE CASE(S) TO OVERSIZED PANEL OPENINGS

NUMBER OF CASE UNITS	TRIMPLATE KIT
1	225155
2	225156
3	225157
4	225190
5	225192
6	225158
7	225194
8	225196
9	225198
10	225200

For ordering information consult the nearest L&N Field Office, listed on the back cover. Supply the Serial No. and Catalog No. of the controller.

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